Discussion Topics

- Rocketdyne Power Systems Heritage
- Current Organizational Overview
- Molten Salt Power Towers
  - System Description
  - Technology / Commercial Readiness
  - Current Status / Path Forward
  - Suggestions for DOE R&D Support
Rocketdyne Power Systems Heritage

1950
First Nuclear Power on US Grid

1960
SNAP 10A: First Nuclear Reactor in Space

1970
Fast Flux Test Facility (FFTF)

1980
Test Facility & Cogeneration Plant

1990

2000

2005

Nuclear
Radioisotope Power Systems (MMRTG)
Gasification Systems
Hydrogen Generators
Commercial Solar Power
Space Station Power System

Fossil

Solar
Rocket Engine Technologies
Gasification Pilot Plant
Fluidized Combustion
Kalina Plant
Solar 1 & 2

Solar 1 & 2

Commercial Solar Power
United Technologies Corporation (UTC)

- $42.7B Sales (2005)
- $5.2B Operating profit
- > 200,000 employees
- Operating in 180 countries
Segment Revenues

60% Commercial
- 28% Carrier
- 24% Otis 24%
- 8% UTC Fire & Security

40% Aerospace
- 11% Hamilton Sundstrand
- 22% Pratt & Whitney
- 7% Sikorsky
UTC Pratt & Whitney acquired Rocketdyne Propulsion & Power from Boeing

- August 2005
- Pratt & Whitney Rocketdyne, Inc
  - Combined P&W Space (West Palm Beach) and Rocketdyne Propulsion

Hamilton Sundstrand given responsibility for Advanced Power systems
Rocketdyne Energy Systems Across UTC

Hamilton Sundstrand
UT Research Center
UTC Power
Pratt & Whitney

Space Land Sea Rocketdyne
Pratt & Whitney Rocketdyne
Power Systems

Terrestrial Programs

Technology Demonstrated
Building Gasification Demonstrator on DOE contract
H₂ Generator in test
Molten Salt Power Tower

**Description of Plant Operations**

1. Sunlight is concentrated and directed from a large field of heliostats to a receiver on a tall tower.

2. Molten salt from the cold salt tank is heated to 1050 F and pumped through the receiver where it is stored in a hot tank.

3. The heated salt from the receiver is stored in a hot salt tank.

4. Molten salt is pumped from the hot salt tank through a steam generator that in turn creates steam that turns a turbine and generates electricity.

5. Cold salt at 550 F flows back to the cold salt tank.

**Diagram:**

- Central Receiver
- Power Tower
- Heliostat
- Storage Tanks
Power Tower Plant Options
Flexibility to Meet Specific Customer Needs

A fixed receiver & collector system can address a variety of power requirements

Tailored Storage and Turbine

- 200 MWe for 4 hrs/day
- 100 MWe for 8 hrs/day
- 50 MWe for 16 hrs/day
- 33 MWe for 24 hrs/day

Power (MWe)

Full Power Operation (hours)
Power Towers Successfully Demonstrated
Solar Two Validated Design, Performance, & Operation

- Plant Dispatchability
  - Demonstrated electric power 24 hr/day
- Power Output
  - Exceeded performance targets
- Receiver Performance
  - Exceeded prediction (receiver efficiency 88%)
  - Achieved design temperatures, flow rates, & pressure drops
  - Demonstrated “normal” & “off-normal” operations
- Pump Performance
  - Demonstrated full-flow at design pressures
- Thermal Storage
  - Demonstrated high efficiency storage

Technology Demo
1994-1998
Barstow, California

Hamilton Sundstrand
A United Technologies Company
Current Status & Path Forward

- Technology successfully demonstrated
  - Key attributes - thermal storage / dispatchability
- Ready now for commercial market entry
  - Environment has changed since Solar 2 demonstration
    - External - global awareness of & interest in CSP
    - Internal – UTC willingness to pursue new market area
  - Leveraging Solar 2 “lessons-learned” to manage project risk
    - Limit to evolutionary improvements for early projects
    - Continue parallel R&D for downstream project improvements
  - Leveraging state / federal / global mandates & incentives
- Key strategic alliances being developed
  - Leveraging strengths to develop world-class team
Suggestions for DOE R&D Support

• Continuous improvements to enhance project attractiveness
  - Enhance technical performance
  - Reduce project risks / uncertainties
  - Reduce capital cost
  - Reduce O&M cost

• Emphasis on major cost / risk drivers
  - Heliostats
  - Molten salt components
    - Pumps
    - Valves
  - Molten salts
  - Materials
  - Coatings

Key Requirements

• Long-life
• Reliable performance
• Lower costs
• Multiple suppliers
Summary

• Power Tower Technology
  • Successfully demonstrated at Solar 2
  • Achieved continuous improvements post-Solar 2
  • High efficiency heat retention enables power dispatch when needed

• UTC – Rocketdyne Power
  • Developing key strategic alliances and actively pursuing power projects
  • Leveraging mandates & incentives for early projects
  • Investing in parallel R&D to enhance future market attractiveness

Collaboration with DOE / National Labs can facilitate near-term project success and long-term growth